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LIFE HISTORY AND LARVAL DESCRIPTION OF *EXEMA ELLIPTICA* KARREN (COLEOPTERA: CHRYSOMELIDAE) ON *BACCHARIS HALIMIFOLIA* L. (ASTERACEAE) IN TEXAS[1]

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Abstract.—Adults and larvae of the chrysomelid *Exema elliptica* Karren feed on leaves of *Baccharis halimifolia* L. along the southern and eastern coasts of the southern United States. In Texas, there were three generations per year. Adults fed for two to three weeks before mating and ovipositing. Females mated often, laid an average of 178 eggs, and lived 139 days. Eggs were covered by the female with a case composed of partially digested leaf particles. The egg case became the protective case of the larva. In the laboratory, eclosion occurred in about 11 days if moisture was available. Larvae without a case did not survive. There were four larval instars. A taxonomic description and diagnostic characters are given of the fourth-instar larva and pupa.

Key Words: Chrysomelidae, Chalamisinae, *Exema,* biology, taxonomy, *Baccharis,* Asteraceae

The woody shrub sea myrtle or consumption weed, *Baccharis halimifolia* L. (Asteraceae), is a native perennial shrub that grows in pastures, brackish swamps, and coastal areas from Texas to Florida and north to Massachusetts (Tarver et al. 1979, Boldt 1989). It is considered a weed because it is unpalatable as forage and its leaves contain a cardiotoxic glucoside that may be toxic to livestock and wildlife (Manley et al. 1982). In Florida, *B. halimifolia* blooms in September and October and produces pollen that causes hayfever (Wodehouse 1971). Shrubs of *B. halimifolia* are unisexual, 1–4 m in height, and grow in thick stands.

The genus *Exema* Lacordaire of America, north of Mexico, has nine species, most of which feed on plants in the Asteraceae (Karren 1966). Larvae of *Exema* are casebearers. Adult appendages fit into body grooves and their distinctive form and dark color give them the appearance of caterpillar frass or other debris (Brown 1943). Four species of *Exema* occur on *B. halimifolia*: *E. deserti* Pierce, *E. gibber* (Fabricius), *E. neglecta* Blatchley, and *E. elliptica* Karren (Karren 1966, Palmer and Bennett 1988). *Exema elliptica* probably feeds only on *Baccharis.* In Texas, Palmer (1987) observed heavy infestations of larvae and adults on leaves and stems of small shrubs of *B. halimifolia.* He did not find *E. elliptica* on a reported host, *Iva frutescens* (Asteraceae) (Karren 1966), and considers this to be a misidentification because it is similar in appearance to *B. halimifolia.*

Materials and Methods

Field studies.—This study was part of a general survey of the phytophagous insect

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fauna of *B. halimifolia*. Observations were made at three sites, one to two ha. each, in abandoned pastures near Waller, Waller Co.; Port Lavaca, Calhoun Co.; and along a roadside ditch at Indianola, Calhoun Co., Texas. Each site contained 50 to 150 plants of *B. halimifolia*. The number of larvae, pupae, and adults was assessed monthly by sweeping 10 plants at each site, selected without bias, from August 1986 to December 1988.

Laboratory studies.—Laboratory experiments were conducted in September 1986 or from June to August 1989 and 1990. Experiments were conducted at room temperature of 25 ± 1°C, relative humidity of 40 to 60% and 14:10 h L:D photoperiod under artificial light. Leaf consumption, egg and larval head capsule measurements were made with a calibrated ocular grid or micrometer in a stereomicroscope.

Egg size was determined by measuring live eggs, 0 to 48 h old, with and without cases. The effect of moisture on egg eclosion was determined by holding groups of 0- to 24-hour-old eggs, selected without bias, on filter paper in separate petri dishes. Each group was moistened with distilled water beginning 0, 2, 4, 6, 8, 10, 16, or 30 days after oviposition. Once moisture was introduced, it was supplied every two days. There were 3 to 5 replications of 5 to 15 eggs each. Treatment means were analyzed with the Kruskal-Wallis one-way analysis of variance by ranks test (MSTAT 1985).

The number of larval instars was determined by collecting larvae, 0 to 24 hours old, as they emerged from eggs and rearing them through successive instars. About 15 larvae in each instar were preserved in 70% ethanol and their head capsule widths were measured. Larval leaf consumption and longevity were determined by placing each of 10 larvae, 0 to 24 hours old, in separate 25 ml plastic vials with freshly excised leaves of *B. halimifolia*. Leaves were replaced three times weekly and the amount of feeding was measured with a 1 mm^2 plastic grid. Two drops of water were added to a 3 cm^2 piece of absorbent paper placed in the bottom of each vial to maintain humidity.

Pupae and adults were collected for oviposition studies. Pairs of one-week-old copulating adults were placed in separate petri dishes with leaves of *B. halimifolia* and held until death. Leaf consumption, number of eggs laid, number of copulations per female, and male and female longevity were recorded.

Morphology.—The larvae and pupae of *E. elliptica* on which the descriptions are based were collected at Indianola, Calhoun County, Texas, on August 23, 1990, from *B. halimifolia*. Larvae of *E. deserti* were collected at Frijole Ranch, Guadalupe Mountains National Park, Culberson County, Texas, on September 20, 1990, from *Baccharis pteronioides* DC. Terminology follows that of LeSage (1982). Insect voucher specimens of larvae, pupae, and adults have been deposited in the National Museum of Natural History, Washington, D.C.

Results

Field studies.—Three generations of *E. elliptica* per year fed on *B. halimifolia* in 1987 and 1988 at Indianola and Waller, Texas (Fig. 1). The first generation of adults was observed in January and February and coincided with the advent of new leaves. The second generation of adults emerged in July and August and overlapped the third generation that appeared in September or October and November. Our sampling initially detected only the summer and fall generations of adults at Waller. However, we collected many young larvae in April 1988 that confirmed the presence of a spring generation. At Indianola, adult population decreased from a high of 14.8 adults per plant in 1987 to 2.3 adults in 1988. This decrease was probably due to a severe drought that lasted from September 1987 through the end of the sampling period in 1989 (NCDC 1988). Many shrubs of *B. halimifolia* were

Table 1. Effect of moisture on development of eggs of *Exema elliptica*.

No. of Days Without Moisture[1]	No. of Eggs	Percent Eclosion[2]	Number of Days to Hatch[2]	Standard Deviation
0	34	73.5[a]	10.8[a]	±0.9
2	36	73.5[a]	9.8[a]	±1.1
4	35	74.3[a]	11.2[a]	±0.9
6	37	78.4[a]	11.3[a]	±0.8
8	46	60.9[a]	11.0[a]	±1.0
10	49	76.6[a]	11.2[a]	±0.7
12	44	81.8[a]	13.4[b]	±0.9
14	49	10.8[b]	15.0[b]	±0.8
16	26	0	—	—

[1] From day of oviposition.
[2] Means in a column followed by the same letter are not significantly different ($P = 0.05$) based on the Kruskal-Wallis test.

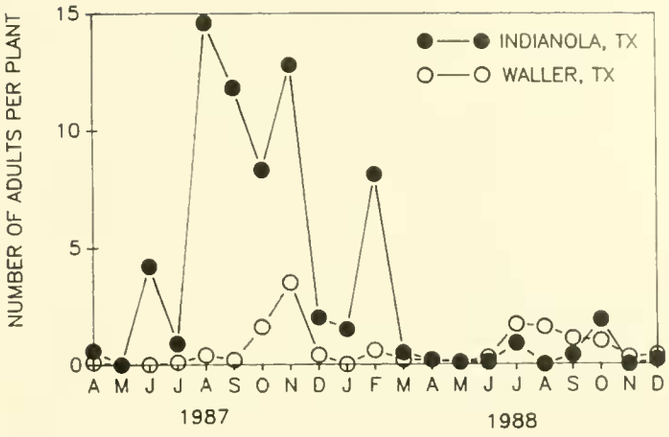


Fig. 1. Seasonal distribution of adults of *Exema elliptica* on *Baccharis halimifolia* in Texas.

severely defoliated, damaged, or killed due to a reduction of 55% in rainfall.

Larvae and adults fed on both sides of the leaf, leaf petioles, and occasionally on green stems. Adults were present on all parts of the plant through the year except mid-summer when they sometimes clustered on new leaf growth near the ground. When disturbed, adults hid on the underside of the leaf near the axil or dropped to the ground. This response of falling when disturbed probably caused us to underestimate the actual population of *E. elliptica*.

Eggs were laid on both sides of the leaf in bell-shaped cases, each attached to the leaf surface with a short, twisted stalk. Larvae were continuously present in the field from April to November, usually feeding on the upper surface of the leaf. Pupation occurred on small stems or occasionally on the leaf.

Laboratory studies.—Eggs of *E. elliptica* were oblong, smooth, and light yellow in color. Most of them were covered with a 0.2 to 0.3 mm thick case apparently composed of partially digested leaf particles held together with a sticky secretion. Females who were interrupted while covering an egg, usually by another adult, abandoned uncovered or partially covered eggs. Encased eggs measured 1.0 ± 0.1 mm length × 0.6 ± 0.1 mm dia. (n = 25, $\bar{x}$ ± SD) while the uncovered eggs measured 0.7 ± 0.03 mm length × 0.4 ± 0.02 mm dia. (n = 15).

Eggs of *E. elliptica* did not diapause, but water absorption was required for egg eclosion. Eggs moistened before they were 10 days old hatched in 9.8 to 11.2 days after wetting (n = 200 eggs, Table 1). Eggs moistened when they were 12 to 14 days old hatched 1.0 to 1.4 days later. Mortality was greatest in the 14-day-old eggs (n = 93 eggs). Eggs that did not receive water within 14 days did not hatch. At the end of the experiment, unhatched eggs were found to contain normal-appearing larvae. This indicated that water was not required for embryo development. In the field, eggs may hatch after a rain to assure the larvae of new leaf growth (Tauber et al. 1986).

At eclosion, neonate larvae chewed away the top of the egg case and broke the stalk that attached it to the plant. They remained in the case but carried it over them with only head and legs exposed. Thus, the original egg case became a protective case. In our ovipositional study, one percent (13 of 1221 eggs) of the eggs laid were not covered or only partially covered. In our rearing colony, where the density of adults was higher, the number of uncovered eggs was much greater, probably because the female was disturbed more often by other adults. Neonate larvae initially wandered about their

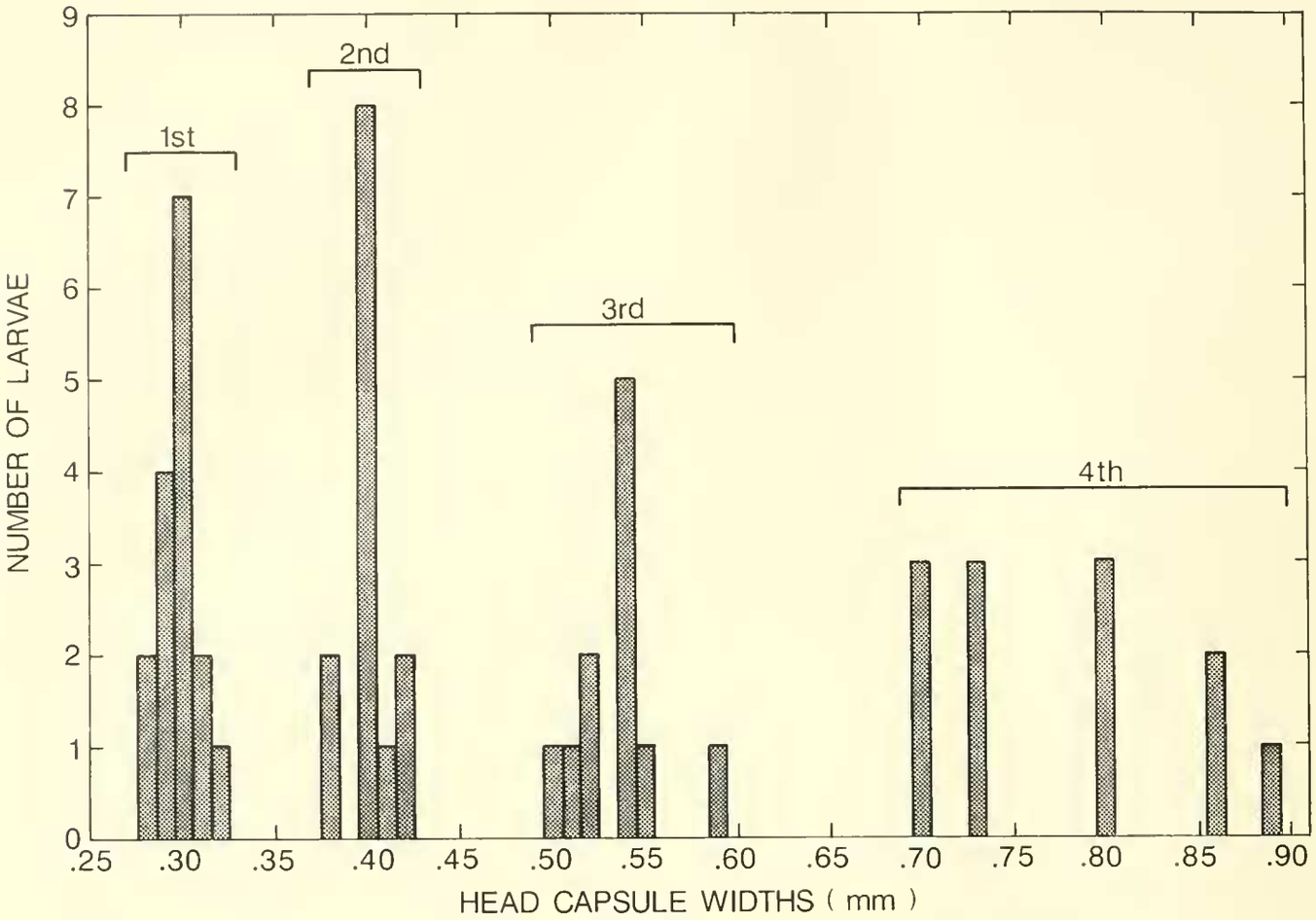


Fig. 2. Frequency distribution of head capsule widths (mm) of larvae of *Exema elliptica*.

container for up to two days without feeding. Only when they found free water did they stop, appear to drink, and then began to feed. Larvae from eggs without a case or that left their case always died.

There were four larval instars (Fig. 2). Head capsule widths were 0.29 ± 0.01, 0.39 ± 0.01, 0.52 ± 0.01, and 0.78 ± 0.09 mm for the first, second, third, and fourth instar, respectively. During each molt the case was attached firmly to the leaf by several white threads for two to three days. Second and third instar larvae placed their cast exuviae at the top of the case but fourth instar larvae left the exuviae on the floor of the case. As larvae grew, they enlarged their case by adding chewed leaf particles to the edge. The cases of third and fourth instar larvae have a nipple at the top that is the remainder of the original egg case. Brown (1943) regards this nipple to be an identifying characteristic of the genus.

The larval parasites *Anastatus* sp. (Hymenoptera: Eupelmidae) and *Aprostocetus* sp. (Hymenoptera: Eulophidae) were infrequently reared from field collected larvae.

After emergence, adults fed for about 2 weeks before mating. Feeding occurred on the leaf petiole or on either side of the leaf. Usually only the surface of the leaf was eaten but holes occasionally were eaten in small or thin leaves. During courtship, copulating males faced the posterior of the female and sat in an upright perpendicular position on the flattened fifth abdominal pygidium. The pygidium did not necessarily touch the substrate and the female, when disturbed, would move with the male still attached. All females mated frequently throughout their life. Copulation in this study occurred an average of 16 times per female.

Females laid 178.9 ± 99.2 (n = 9) eggs. The greatest number of eggs laid by one female was 329. During oviposition the fe-

male attached one end of the egg to the substrate with a stretchable (ca. 1 mm long) stalk and, holding the egg under her abdomen, twisted the stalk by slowly rotating the egg with her rear legs. At the same time, a viscous, particulate fluid was secreted from the tip of the extended abdomen. The particles were probably bits of digested plant material. An inverted, bell-shaped case gradually formed around the egg from its base to its top. Finally, the exposed tip of the case was packed with particulate material by the tip of the abdomen to form a concave cap. The case soon hardened and turned brown. Females lived 139.4 ± 21.9 days (n = 9) and males lived 122.0 ± 39.4 days (n = 9).

Morphology
Figs. 3–8

Fourth instar larva.—Body strongly bent ventrally with apex of abdomen directed downward or forward; body widest at 5–7th abdominal segments; legs elongated, directed forward. Head pale brown to dark brown. Body white. Legs: coxae pale brown to brown; femur and tibiae pale brown to nearly white. Length—3.8 to 4.5 mm.

Head: Hypognathous, ovoid, evenly rounded, from anterior view length slightly greater than width; distinctly pigmented, varying in color from pale brown to dark brown, lightest at sides. Epicranial suture distinct, Y-shaped, upper arm impressed and darkly pigmented at about basal half, remainder of suture shallow and marked by a light furrow, each lateral arm angled downward at about its midlength.

Ocelli well-developed, each side of head with 6 ocelli, four located above antenna, two below antenna.

Epicranium (Fig. 7) with 5 pairs of dorsal epicranial setae (des) each side, des 1 on disk below sensillum (deml), des 2 lateral to des 1, des 3 above and des 4 below paired sensillae desm 2 and desm 3, des 5 above superior ocelli.

Frons with 4 pairs of frontal setae forming three transverse rows, fsl above front sensillum (fsm), fs2 below fsm, fs3 and fs4 in lower third of frons, with no fs5. Frons partially fused with clypeus, no suture evident in median area.

Clypeus fused with labrum. Two pairs of clypeal setae (csl–2) located medially in fused area of frons and clypeus.

Labrum transverse, apex sinuated, behind apex with a median, sinuated, chitinized area. Three pairs of labral setae (lbs) present, labral sensilla (lbesm) above lbsl.

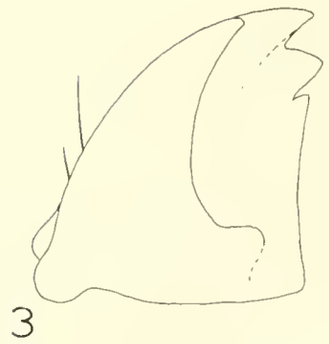
Epipharynx with 5 pairs of spiniform submarginal ephipharyngeal setae, inner and outer pairs largest; epipharyngeal sensillae in three groups, two groups of 6 sensillae each side basally, one median group of 10 sensillae apically; apex of epipharynx ending in a dense bunch of spinules.

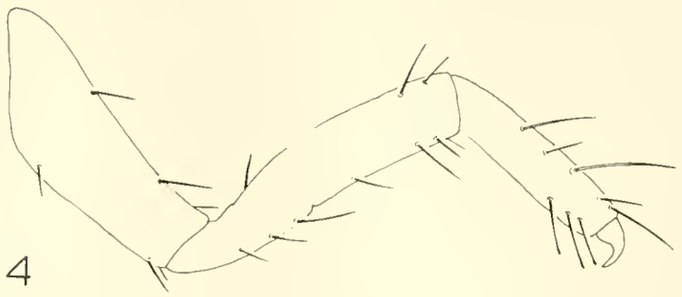
Antenna small, two-segmented; first segment a little wider than long and bearing two sensillae; second segment about as long as wide, apically bearing a number of spinules, one longer than others; at apex with a conical papilla.

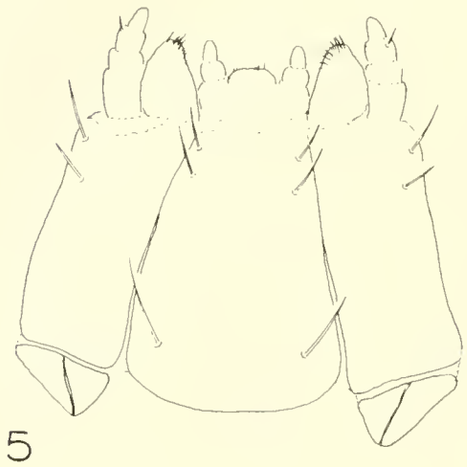
Mandible (Fig. 3) stout, four-toothed, without mola and retinaculum; mesal surface evenly concave, inner dorsal edge nearly straight; one large mandibular seta located on outer edge, toward base with a smaller seta.

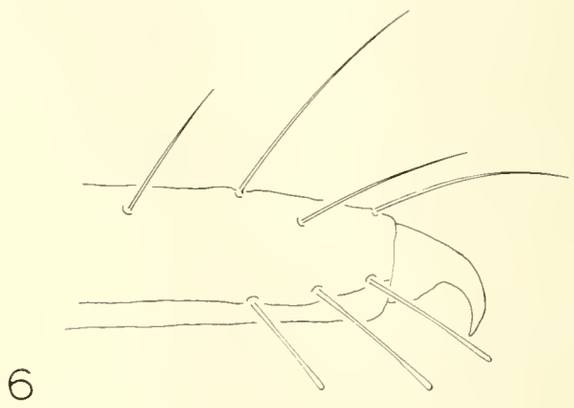
Labium (Fig. 5) prementum and postmentum not fused. Postmentum bearing 3 pairs of setae, of which one pair is large, located basally, the other two located apically, with the small pair anterior to the larger pair, and a sensilla located between them. Prementum with a large seta near base of each palp, with tiny setae apically between palps; labial palp two-segmented, each segment with a sensillum, last segment with a number of spine-like processes.

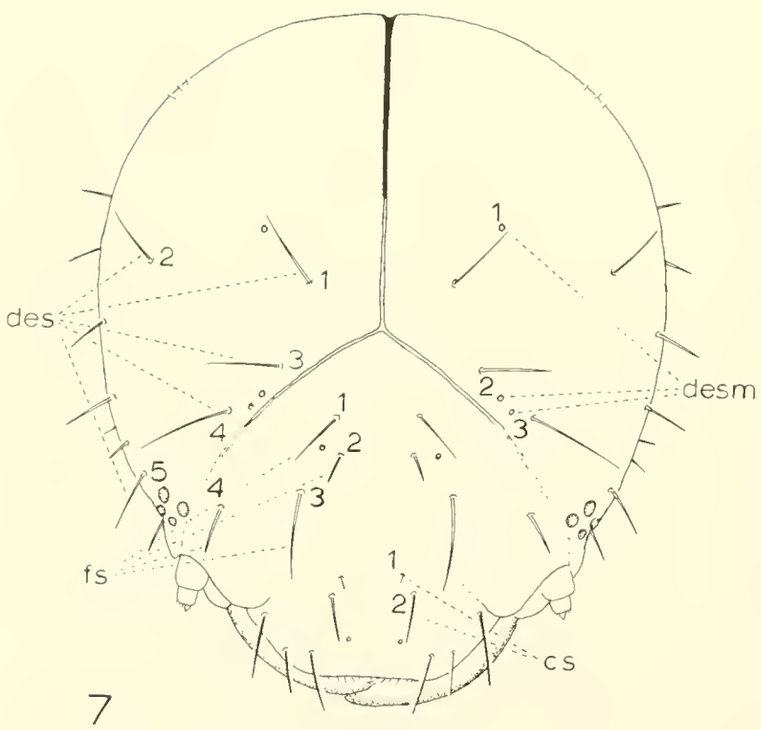
Maxillary cardo of 2 fused sclerites. Stipes large, elongated, bearing 2 large, outer setae and one small, inner seta. Mala bearing eight or ten stout setae of varying sizes. Maxillary palpus four-segmented, segment 1 with 2 large basal setae and 1 sensillum; segment

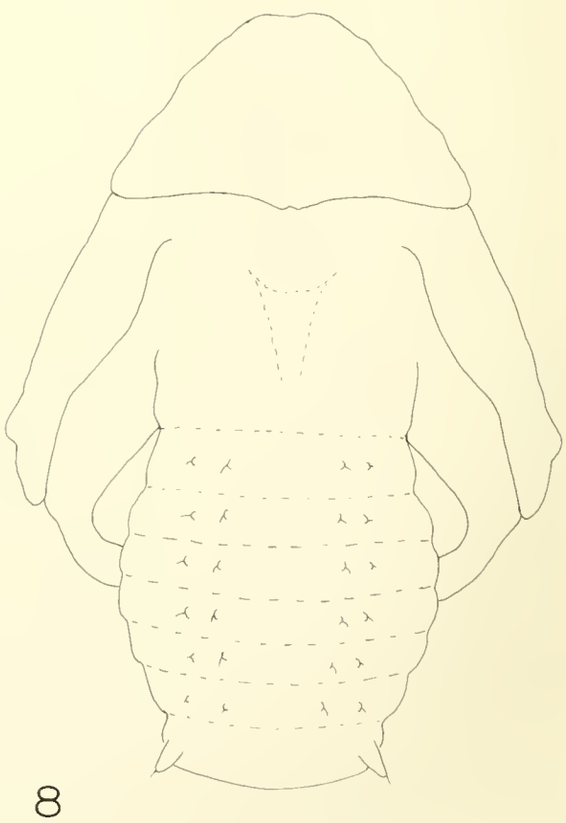












Figs. 3–8. *Exema elliptica,* larva and pupa. 3, mandible. 4, prothoracic leg. 5, labium. 6, tibiotarsus. 7, head capsule. 8, pupa.

2 without setae but with 2 sensillae, segment 3 with 1 outer seta, a small inner seta and a sensillum, segment 4 with a sensillum and minute apical spicules.

Thorax: Cuticle largely colliculate, pronotum weakly sclerotized; setae of varying sizes, mostly along anterior margin, a few along posterior margin, nearly absent on disk, with 3 or 4 sensillae along anterior margin each side of midline. Meso- and metanotum not sclerotized, bearing a few, small setae. Prothoracic spiracle large, bean-shaped, with one opening.

Pro-, meso-, and metathoracic legs (Fig. 4) nearly identical in size, shape, and chaetotaxy. Each leg long, slender, primarily white, but basal segment of each light to medium brown and with base and apex narrowly white; with claw-like tarsungulus. Setae as shown in figure. Tibiotarsus (Fig. 6) of each leg with three pairs of ventral setae forming two rows, apices of setae more or less clubbed. Claw arcuate, basal thickening bearing a single seta.

Abdomen: Bent downward or forward, not sclerotized, broadest at 5th–7th segments. Cuticle largely colliculate. Segments with sparse, long and short setae. Spiracles annular, on Segments I–VIII.

Pupa.—White throughout, bare, with no chitinized features and few setae; length 3.6 mm, width 1.7 mm. Head directed downward and concealed from above. Pronotum broad, nearly two times as wide as long, disk protuberant, basal margin at middle as a widely spread W. Wing pads bare and extending to fourth abdominal segment. Pedothecae bare, may be partly visible from above. Mesonotum strongly transverse, bare, somewhat protuberant posteriorly at middle. Metanotum transverse, bare, about 1.5 times as long as mesonotum. Abdomen mostly bare, segments 1–6 with setae (moderate in length) set on small mounds, number of paired setae per segment as follows: segment 1 with 2; segments 2–3–4– with 3; segments 5 and 6 with 2. Abdominal segment seven with a long fleshy mound each side bearing a seta; segment eight bent downwards, non-setate, not visible from above.

Diagnostic characters.—In addition to *E. elliptica,* specimens of *E. deserti* and *E. canadensis* were inspected. For a drawing of the larva of the closely related *E. canadensis,* see LeSage (1982). The following notes result from examination of the specimens.

Larvae of *elliptica, canadensis,* and *deserti* may be distinguished by leg and head characters: *elliptica* has the tibiotarsus of each leg with 3 pairs of ventral setae forming 2 rows and each side of head with epicranial setae 1–2–3– non-equidistant, des1 and des3 are clearly closer to one another than they are to des2; *canadensis* has the tibiotarsus of each leg with 4 pairs of ventral setae forming 2 rows and each side of head with dorsal epicranial setae 1–2–3 about equidistant from one another; *deserti* has the tibiotarsus of each leg with 3 pair of ventral setae forming 2 rows and each side of head with dorsal epicranial setae 1–2–3 about equidistant from one another.

The pupae of *elliptica* and *canadensis* can be distinguished by abdominal setae. The pupa of *elliptica* has abdominal segments 1–6 each with 2 pairs of setae. *E. canadensis* pupa has abdominal segments 1–5 each with 1 pair of setae and segment 6 with 2 pairs.

Pupae of *E. deserti* were not examined. For a presentation of the characters which will distinguish the adults of the species of *Exema,* see Karren (1966).

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